Towards precision radial velocity science with SALT's High-Resolution Spectrograph

December 2020

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SPIE 11447-287

ABSTRACT

We describe our efforts to develop precision radial velocity (PRV) capability for the High-Resolution Spectrograph (HRS) on the Southern African Large Telescope (SALT). The instrument's high-stability (HS) mode offers an iodine cell or a simultaneous ThAr calibration feed for PRV science. The new iodine cell delivers 3-4 m/s RV stability, but only for the brightest stars (V<6). The internal stability of the instrument is now being quantified to evaluate the viability of the simultaneous ThAr option. This involves injecting arc light into the object and calibration fibres at once and measuring relative shifts between the two over time. This required modification of the feed optics for the HS mode and the development of analysis tools to measure the miniscule shifts. Initial results show sufficient stability so SALT will likely pursue development of a laser frequency comb to support HRS PRV work.

SALT HRS

This is a fibre-fed, dual-channel, white-pupil vacuum échelle spectrograph with low (15k), medium (40k) and high (65k) resolution modes. The high-stability mode (65k), designed for PRV work, employs a fibre-double-scrambler and either an iodine cell, or simultaneous ThAr injection into the sky fibre for precise wavelength calibration. We need to establish whether this general purpose facility instrument is equal to the highly specialised task of pursuing exoplanet science.

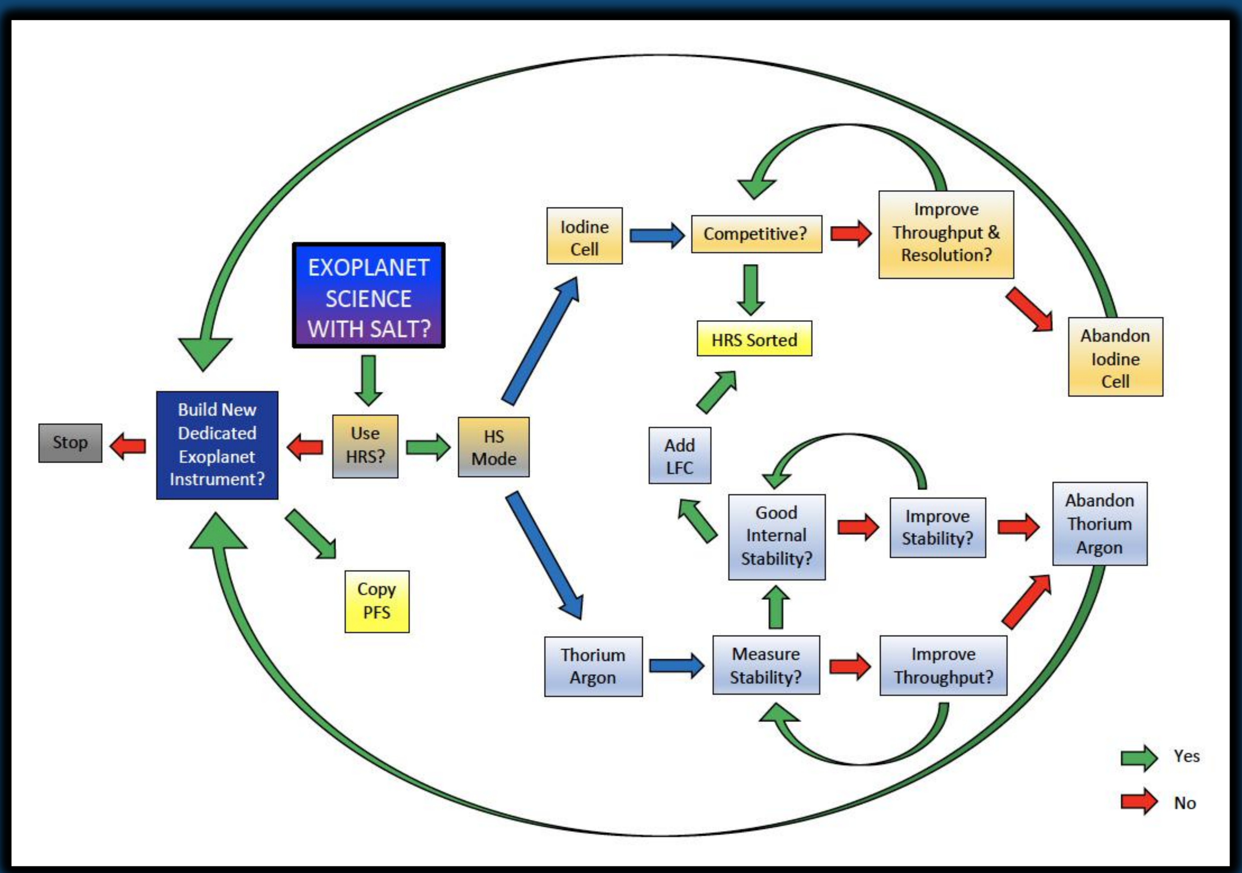

Fig. 1: Flow chart for exploring the suitability of SALT HRS for PRV science.

New Iodine Cell

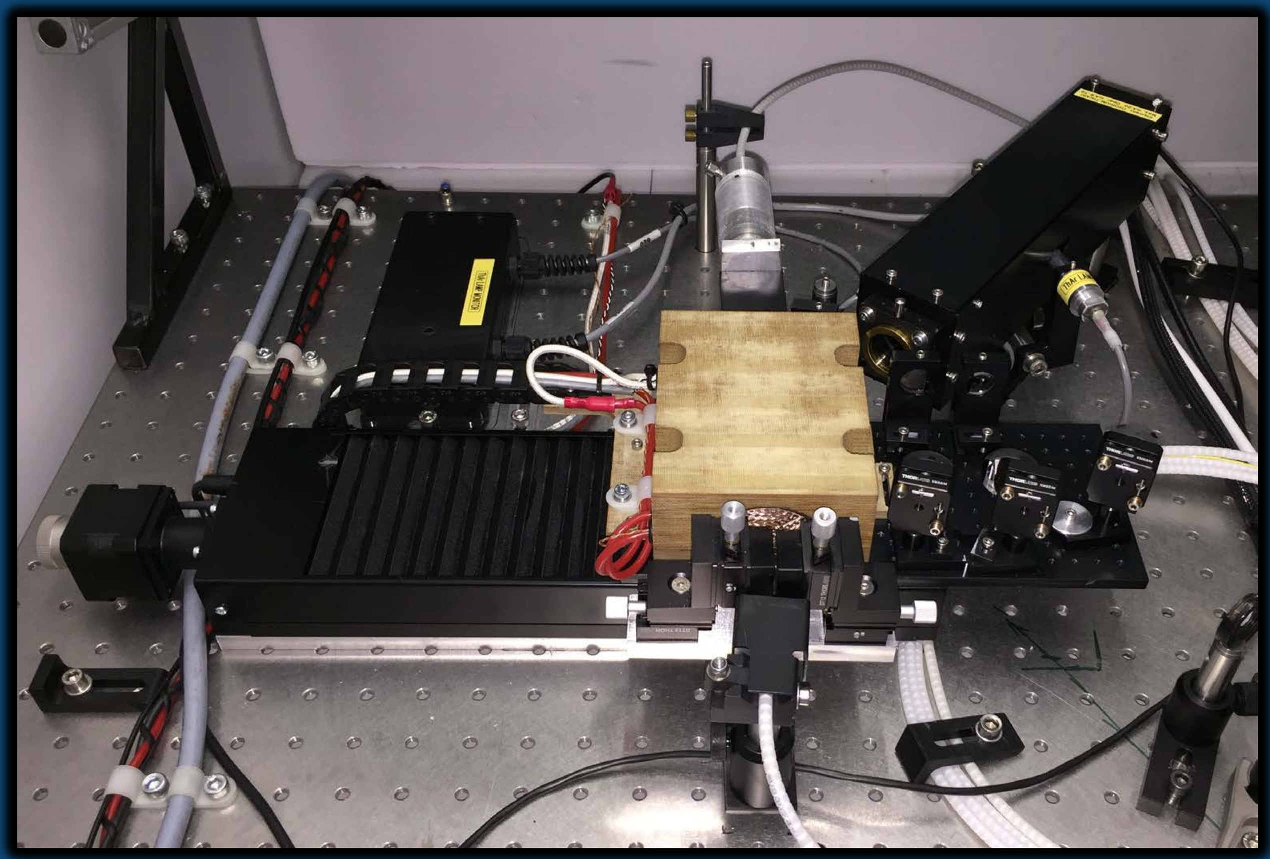

Fig. 2: The new iodine cell is fully integrated into HRS science operations.

Previously we reported the results of our engineering tests with a new iodine cell. That cell has since been incorporated into the HS bench and made operationally robust. Regular observations of a bright (V=4.9 mag) stable star indicate stability at the 3-4 m/s level over the course of a year, using 3x5 min exposures.

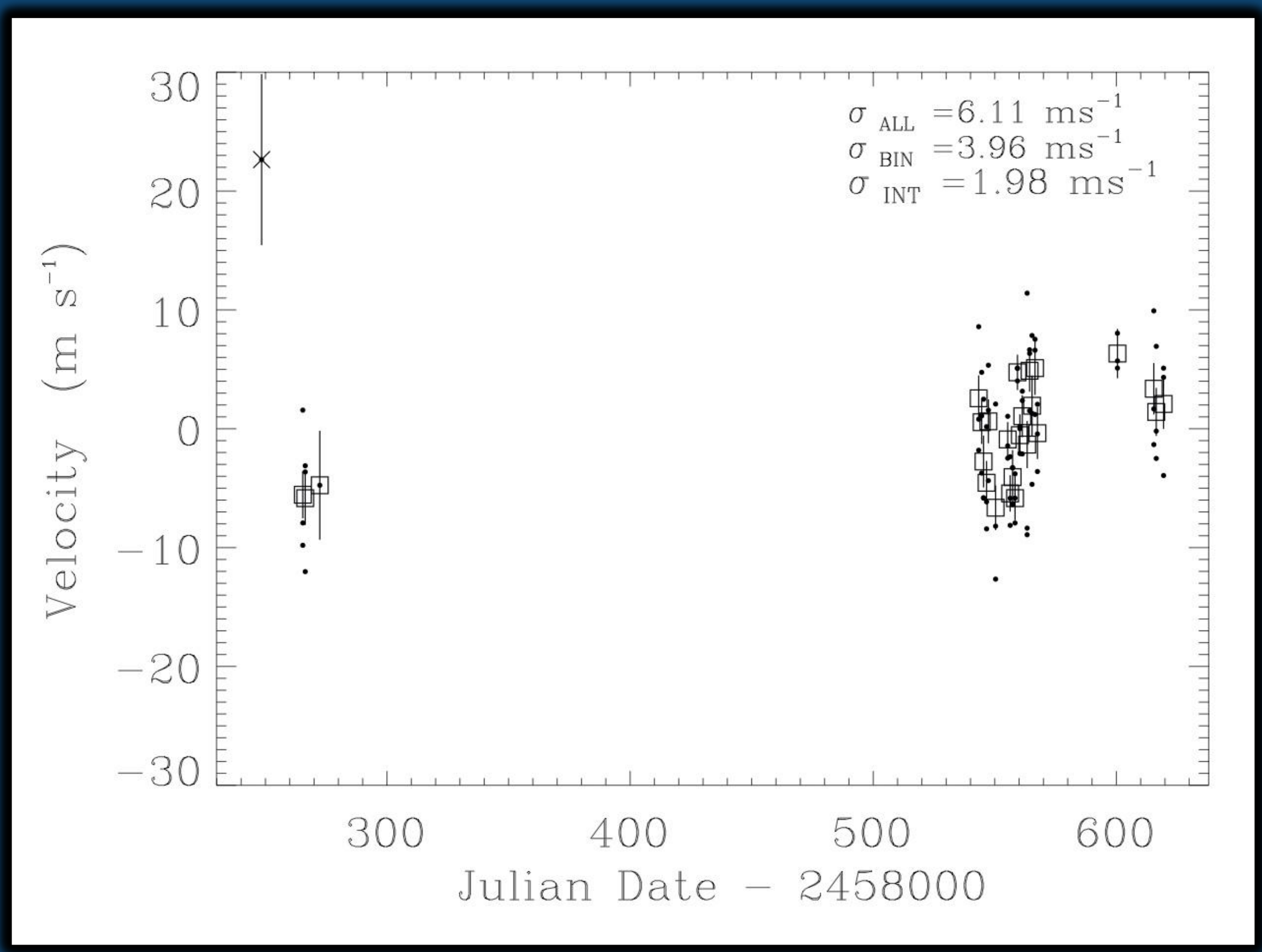

Fig. 3: Long-term iodine cell monitoring of a bright stable star, HD102365.

We are therefore able to achieve 5-10 m/s on V=7 and 8 mag stars using 3x10 min exposures. SALT's pointing restrictions (that result in target visibility windows often being limited to under an hour), place disappointing limits on how faint we can observe with the iodine cell.

Simultaneous ThAr

Next we characterised the HS mode's simultaneous ThAr option. The intrinsic stability of the instrument is determined by comparing drifts between the object and calibration fibres. This required a new optical feed (50/50 beam-splitter + fold mirror) to direct ThAr light into both fibres at once. 90 sec arcs were taken at 10 min intervals over two days (the telescope being idle during the days, but operational at night). New analysis tools were developed to deal with the resulting frames.

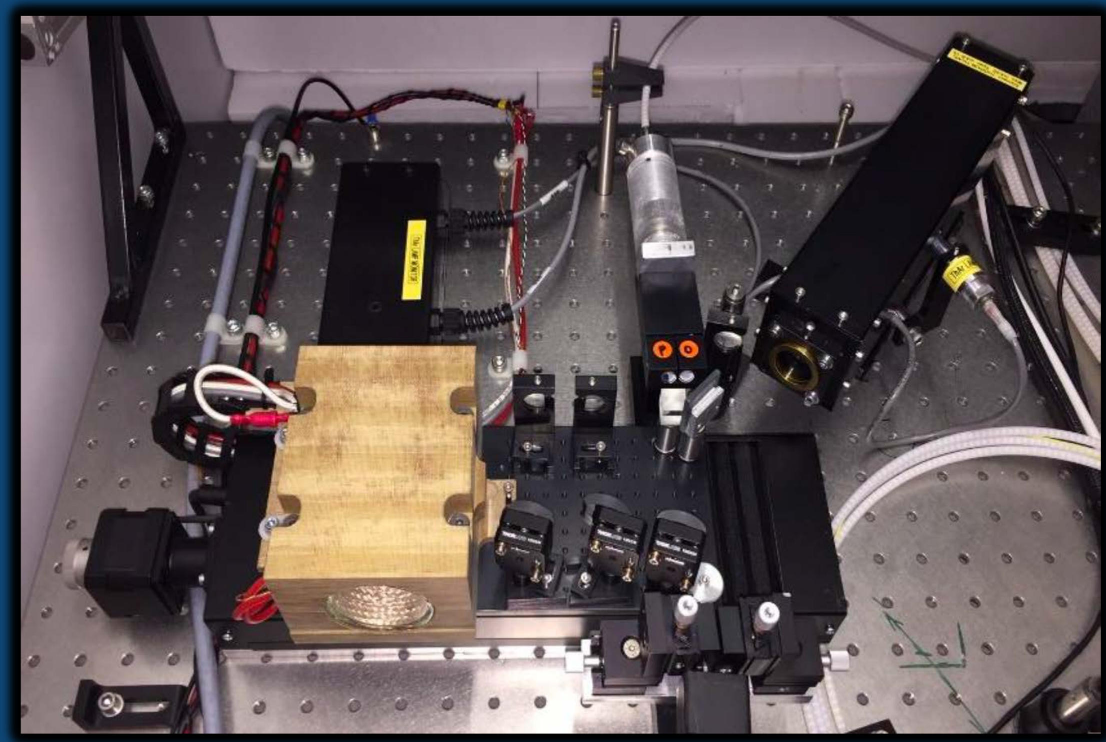

Fig. 4: Instrumental stability monitoring required new feed optics to allow arc light to be injected into both HS mode fibres simultaneously.

The two fibres drift by ~2.5 m/s (black points in Fig. 5) and removing a temperature trend yields residuals at the 40 cm/s level (blue points). Though further testing is needed, SALT is now exploring laser frequency combs.

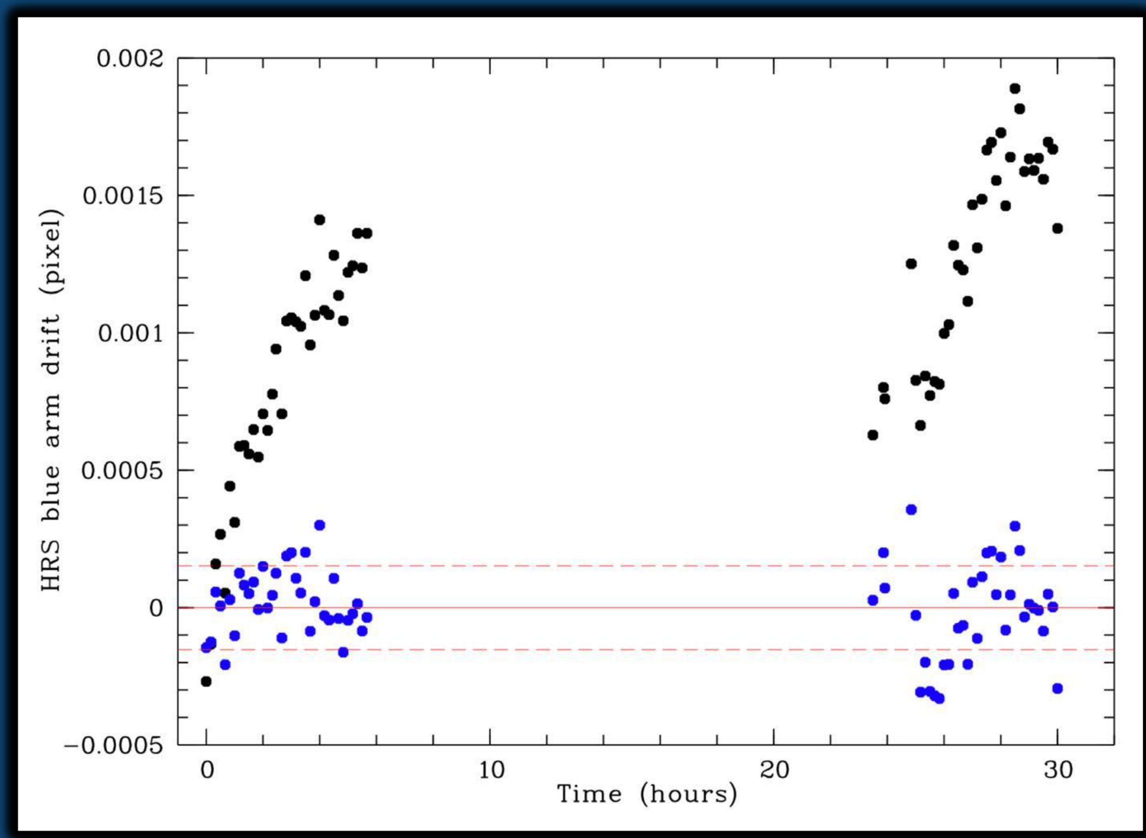

Fig. 5: We find 2.5 m/s object/calibration fibre drifts (black) and 40 cm/s residuals (blue) after removing a temperature trend that is well approximated by a 2nd order polynomial.

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